CAAP Quarterly Report

Date of Report: *June 30th, 2019*

Contract Number: *DTPH56-16-H-CAAP03*

Prepared for: *U.S. DOT Pipeline and Hazardous Materials Safety Administration*

Project Title: Development of New Multifunctional Composite Coatings for Preventing and Mitigating Internal Pipeline Corrosion

Prepared by: *North Dakota State University*

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For quarterly period ending: *June 30th, 2019*

Business and Activity Section

(a) Generated Commitments

Kickoff meeting was held at North Dakota State University on June 11st, 2019

Two high-school students from the ND governor's high school program were recruited and participated in the project of Dr. Lin's group

Some purchase for nanoparticles

Dr. Lin attended and presented the poster sections in World Techconnect 2019 on June 17-19.

(b) Status Update of Past Quarter Activities

The research activities in the 11st quarter included: (i) a kick-off meeting with the USDOT PHMSA program director; (ii) the continuing efforts by characterizing the hybrid nano-modified coatings and assess their long-term performance, as summarized below.

-(i) Kick-off meeting

A kick-off meeting was held at North Dakota State University on June 11st, 2019. The USDOT PHMSA program director, Joshua Arnold, had a one-day NDSU campus visit for the kick-off meeting. The meeting agenda and major activities are shown in Table 1, including meeting with PIs and meeting with the student poster section (see photos shown in Fig. A.1), and meeting with Associate Dean of College of Engineering (see Fig. A.2) and department chair of Civil Engineering (see Fig. A.3), and tours to laboratory and facilities at NDSU (see Fig. A.4). This was a great opportunity for the PIs and gradudate students who have been working in the USDOT sponsored projects to communicate with the program director.

Table 1 Kick-off meeting agenda (Tuesday, June 11st, 2019)

Items	**Major Contents**	**Note**
Location	College of Engineering, Dept. of Civil Engineering, Dept. of Coatings and Polymeric Materials, NDSU, Fargo, ND.	
Objectives	a. Funding activities and expectation of the PHMSA b. Introduction and discussion of the project, objectives and tasks c. Meeting with NDSU personnel (PIs and students, Dean of College of Engineering, Department chair of Civil Engineering) for current projects and potential future collaboration d. Visit NDSU facilities, labs and facilities associated with the projects and future collaborative work	
Detailed schedules and activities	9:00 – 10:00 AM, Kick off meeting (Dean's conference room 106) o Joshua gave a big picture of the PHMSA and the current activities. o Joshua discussed with PIs about the expectation of the project and communicated with two PhD students involved in this project for their roles in this project and high expectation to them for involvements in the field of pipeline. o Dr. Zhibin Lin gave a presentation about the current research topics and future plan related to pipeline safety. 10:00 – 11:00 AM, Meeting with students and poster section (CIE 101) 11:30 – 11:00 AM, Meeting with Associate Dean Dr. Scott Pryor 11:30 – 12:00 AM, Meeting with CEE Chair Dr. David Steward 12:00 AM – 1:30 PM, Lunch with the CEE Chair and Dr. Lin and another two graduate students (Applebee's Restaurant, 19TH street) 1:30 –2:30 PM, Lab tour o Joshua visited the laboratory in the Dept. of Coatings and Polymeric Materials (Fig. A.4). o Joshua also visited the laboratories in the research one center at NDSU (Fig. A.4). 2:30 PM, Joshua headed for the airport.	* College Dean and Department Chair appreciate the financial support for PI and potential internship offered for undergraduate and graduate students.

Fig. A.1 PHMSA project director, Joshua Arnold, met with graduate students at NDSU

Fig. A.2 PHMSA project director, Joshua Arnold, met with Associate Dean Dr. Scott Pryor at NDSU

Fig. A.3 PHMSA project director, Joshua Arnold, met with CEE Chair Dr. David Steward at NDSU

Fig. A.4 PH MSA project director, Joshua Arnold, had a lab tour at Research 1 at NDSU

11.1 Objectives in the 11st Quarter

As the proposed high-performance coating is mainly focused on protecting the internal surface of oil & gas transmission pipelines, stronger reinforcement will be obtained if the surface properties of the developed coatings can be improved. The coating systems have incorporated both nanofiller reinforcement and polymer modification. For the modified coating, the high-water contact angle was remained after salt spray or abrasion, indicating the superior water repellency with excellent durability.

Meanwhile, the fabrication of flow instrument designed for field long term performance test was finished and able to test coated panels. Currently, a trial test was conducted to inspect the performance and quality of the flow instrument. More flow instruments will be built if positive results are obtained in the trial test, and this test method will be used to evaluated coating systems.

11.2 Experiment design

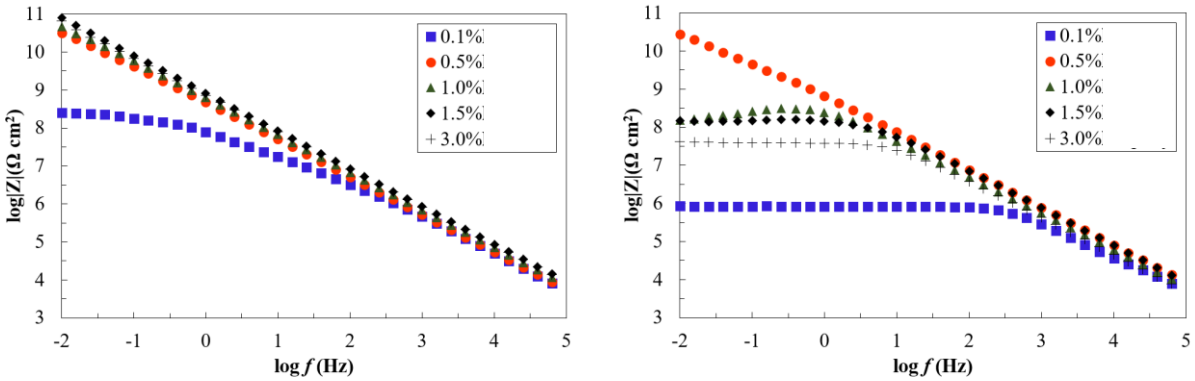
The plan of the experimental study was illustrated in Fig. 2; thus, the following objectives were included:

i. to investigate the effect of nanoparticles' shapes on the coating performance.
ii. To characterize and evaluate the long-term durability of coating performance.
iii. A trial test was conducted with a flow instrument, and this test method will be used to determine the long-term performance of the developed coatings.

11.3 Results and discussion

(a) Corrosion resistance of nano-reinforced epoxy (EIS & B117)

The combination of EIS and B117 salt fog test were performed to characterize the corrosion resistance of the nanocomposite coatings in both the short and long term. As shown in Fig. 1, test resulted confirmed that 0.5 wt.% of nanoparticles could dramatically improve the corrosion resistance of the epoxy coatings.



(a) onset (b) 500-hour exposure

Figure 1. Impedance curve of the nanocomposite coatings: (a) onset, and (b) 500 hours.

(b) Abrasion resistance of fullerene-C60 reinforced epoxy

The Taber abraser test characterized the abrasion resistance of the tested coatings and wear mass loss was measured during the test. Less mass loss after the test indicates the coating has stronger abrasion resistance. Test results demonstrated that all cases exhibited the improved abrasion resistance as compared to the conventional epxoy.

(c) Tensile properties fullerene-C60 reinforced epoxy

The analysis of tensile properties for nanofiller reinforced epoxy was determined by the coupon tensile test, following ASTM D638. The nano-composites were evaluated by measuring maximum tensile stress, strain at failure, and Young's modulus during the test. Results showed the nanoparticles could significantly improve the tensile stress of epoxy, hence; the tensile stress of all the tested groups was higher than 45 MPa while neat epoxy was 24 MPa. Furthermore, a similar tendency was observed in failure strains.

11.4 Long term test with liquid flow instrument

The fabrication of instrument for long-term test with water flow was completed, and the plan view was illustrated in Fig. 2. The test instrument includes four parts: fluid reservoir, pump, valve, and channel to simulated pipeline flows. The channel was designed to test three coated panels at one time, and the panels are removable so EIS test can be performed to evaluate the corrosion resistance after they were exposed to the water flow. Currently, a trial test was running in order to evaluate the performance of the test instrument, and more test setups will be built once the trail test is succeeded.

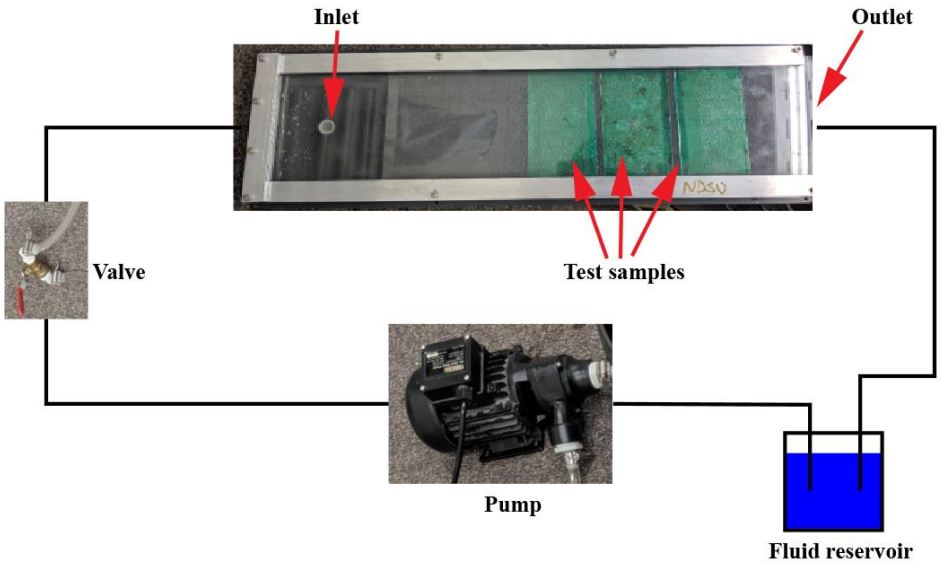


Figure 2. The water flow instrument for the long-term field test

(a) **Description of any Problems/Challenges**

No problems are experienced during this report period

(b) **Planned Activities for the Next Quarter**

The planned activities for next quarter are listed below:

- The water flow instrument will be used to simulate the internal environment of pipelines, and coating performance will be evaluated by this modified field test.